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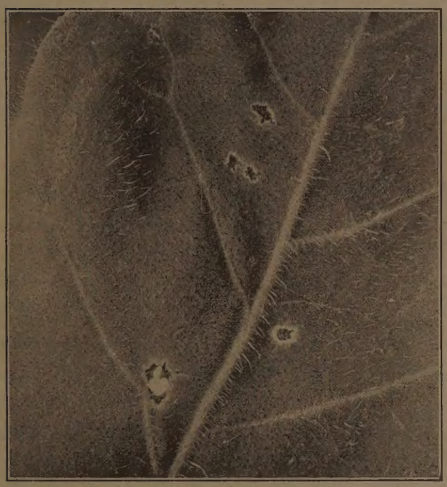
TOBACCO DISEASES IN VIRGINIA AND THEIR CONTROL

By

S. A. WINGARD and JAMES GODKIN



Blackfire spots on a plantbed leaf as they appear when the leaf is held to the light. The spots are angular and are bordered by a clear narrow zone. About twice natural size.

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TOBACCO DISEASES IN VIRGINIA AND THEIR CONTROL

By

S. A. WINGARD and JAMES GODKIN

Introduction

Tobacco has been an important crop in Virginia for more than three hundred years. The colonists at Jamestown grew it on a small scale as early as 1612, and in 1618 more than 20,000 pounds were shipped to England. The crop continued to grow in importance in the State, and the average annual production now is about 150,000,000 pounds, which represents a valuation exceeded, among the other crops of the State, by corn alone.

The long period of years over which the crop has been grown in the State explains, in a large measure, why the many diseases of tobacco occur so generally. An accurate statement of the losses caused by these diseases cannot be made, but it is known that they can be figured only in terms of millions of dollars annually.

During the past few years both the Agricultural Experiment Station and the Extension Division have received numerous inquiries concerning tobacco diseases and their control from growers, warehouse managers, and fertilizer dealers. This indicates that the growers and others interested in the tobacco crop are fully aware of the fact that these diseases are exacting a heavy toll. It shows, too, that there is an increasing desire on the part of the grower to learn more about their prevention and control. It is the purpose, therefore, of this circular to supply the grower with the information now available on these diseases.

The several diseases, in so far as it is practicable, will be discussed in order of their relative importance in the State, and the discussion will be restricted to the most important facts concerning their symptons, cause, and control. Photographs will be used freely in order to aid the grower in distinguishing the different diseases.

The diseases of tobacco may be classified into two groups: those which are caused primarily by specific parasitic organisms or germs; and those which are caused by improper nutrition, or by unfavorable environment. Of the diseases treated in this bulletin, the following are infectious and are caused by specific parasitic organisms: blackfire, wildfire, root rot, black shank, wilt, frog-eye, and root-knot; while the following are not infectious nor caused by parasites so far as is known: ring-spot, frenching, drought-spot, and lightning injury. Mosaic is infectious, but the causative agent has not been discovered.

Growers frequently have mistaken ideas as to the cause of the different diseases of tobacco. This no doubt can be attributed to the fact that the disease-producing organisms are too small to be seen with the naked eye, and it is, therefore, perfectly natural for the grower to attribute diseases to causes with which he is familiar. When the underground parts of the plant are affected, he concludes that the trouble is due to a toxic fertilizer or something of that nature, and if a disease develops during or immediately after a period of rainy weather, the grower almost invariably concludes that it is caused by too much rain. These conclusions are somewhat justified because the parasites or germs which produce these diseases are to a great extent dependent upon the soil and weather conditions for their development. They are living organisms and are just as sensitive to changes in soil and weather conditions as are the higher plants and animals.

Some disease organisms attack the tobacco plant when it is in a weakened condition, while others are more destructive when the plant is in a very vigorous condition. Other factors such as temperature, moisture content, and reaction of the soil play an important part in the development of disease. The influence of these factors on infection explains why it is possible for a disease to be very serious in some years and of very minor importance in others.

The extreme smallness of disease organisms enables them to be carried from farm to farm and from field to field by the following agencies: seed, seedlings for transplanting, wind, drainage water, man, animals, insects, farm implements, plant refuse, etc. The grower frequently spreads disease without being aware of it. The germs multiply so rapidly under favorable conditions that a relatively small number of them will, as a rule, prove sufficient to establish the disease in a new field. Some of these organisms live

in the soil for many years on decaying organic matter, some attack other crops as well as tobacco, while still others infect weeds that grow in and around the tobacco field and persist on them from year to year.

Blackfire and Wildfire

Blackfire and wildfire, although two entirely distinct diseases, have a great deal in common. For this reason, as well as to better contrast their differences, they will be discussed under one head.

Blackfire first appeared in epidemic form in the State in 1917, when it caused severe losses on many farms. There is no definite information available as to the history of the disease prior to that year, but there seems to be little doubt but that it has existed in Virginia for many years. In fact, some growers contend that blackfire was known to their grandfathers. Such reports, however, cannot be accepted as authentic, because other leafspot diseases occur on tobacco and the grower, as a rule, does not distinguish sharply between them.

Wildfire was first reported from North Carolina in 1917. It was discovered in Virginia the following year and has been present to a greater or less extent every year since that time. Many farmers refer to both diseases under the name of wildfire. Many of them, as a matter of fact, do not distinguish between the two diseases, although they recognize the differences readily when they are pointed out.

Blackfire is much more prevalent in Virginia than wildfire. In a survey made in 1920, a year of very heavy losses from these diseases, blackfire was found in 80 per cent of the fields inspected and wildfire in 17 per cent. Both diseases are capable of causing severe losses under favorable conditions, and, in recent years, they have been by far the most destructive diseases of the tobacco crop.

So far as is known, the blackfire germ does not attack any plant other than tobacco. It has been shown, however, that the wildfire germ is capable of infecting tomato, petunia, eggplant, cowpea and pokeweed, but it is not as active a parasite on these plants as on tobacco, and it is rather doubtful whether it propagates on them to any appreciable extent.

Symptoms. — In addition to the spots which these diseases produce on the leaves of growing plants in the field, infection occurs on the flowers, and also on the leaves of the seedlings in the

plantbed. Familiarity with the appearance of infection in the plantbed is especially important since the control of these diseases in the field depends upon the elimination of infection from the plantbed.

FIG. 1. — Wildfire spots on a plantbed leaf. Note the characteristic halo around the spots. Courtesy of F. A. Wolf.

The very general occurrence of infection in farm plantbeds is shown by the fact that 70 per cent of the beds inspected in the State during three seasons were found to be infested with blackfire and 13 per cent with wildfire. Infection is found most readily in the plantbed when the plants have reached the stage of transplanting, and the spots are usually most numerous in those sections of the bed where the plants have made the best growth and are greenest in color.

FIG. 2. — Blackfire spots on a leaf of bright tobacco. The spots are typically angular on this type of leaf.

The blackfire spots on the seedling plants are quite small, angular in shape, and black or dark-brown in color. When the leaf is held to the light, a narrow, clear border is seen surrounding the spots. This feature, which is shown on the frontispiece, is very

characteristic and makes a positive diagnosis possible. The spots on seedling leaves always remain small and never approach the leafspot in the field in size. Infection may occur on any part of the leaf, but the most common location is near the leaf margin a short distance from the tip. The leaf is usually puckered near the point of infection and this feature can be seen from quite a distance. The centers of the spots often crack and in later stages the diseased areas drop out, leaving small holes in the leaf.

FIG. 3. — Blackfire spots on thick leaf of tobacco. The spots are not so angular as those usually found on bright tobacco. About twice natural size.

The wildfire spot on seedlings is easily distinguished from blackfire. It is rounded in shape, with a small brown center surrounded by a broad, pale-green or yellow halo (figure 1). The spots are often found around holes made in the leaves by the flea-beetle.

It is much more difficult to distinguish between these leafspots in the field. The blackfire spot on the field plant is much like the seedling spot in the early stages, but it becomes very much larger when mature. The size and shape varies considerably according to the character of the leaf on which it occurs. On bright

tobacco with thin leaves the spots are typically angular (figure 2) and are generally less than a half inch in diameter. The angular shape of the spot on dark tobacco with a thick leaf is less evident, and on very heavy tobacco the spots become quite rounded in outline (figure 3) and are usually larger than the spots on bright tobacco. The color of the spot varies considerably from a tan to dark-brown. There is no conspicuous halo as in wildfire, but the tissue around the spots is usually yellowed.

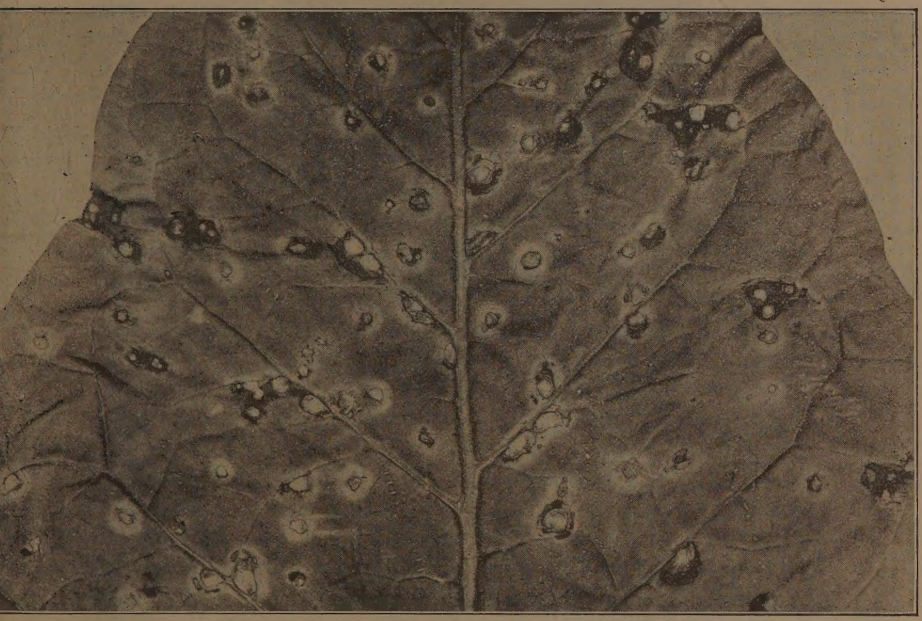

FIG. 4. — Wildfire in medium-early stage of development. The halo is conspicuous at this stage.

The wildfire spot in its early stages in the field is also quite similar in appearance to the seedling spot (figure 4). The halo, however, is not so conspicuous in the mature spots, due to the enlargement of the center, and it is sometimes a difficult matter to distinguish them with certainty from the rounded type of blackfire spots. In severe cases the spots may run together and involve the entire leaf.

Both blackfire and wildfire occur on the flowers and seed pods, especially on the lobes of the calyx. In the case of blackfire the lobes of the calyx become blackened and recurved, as shown in figure 5, while wildfire produces small, dark, irregular spots on the corolla and calyx, and prominent brown spots on the pods (figure 6).

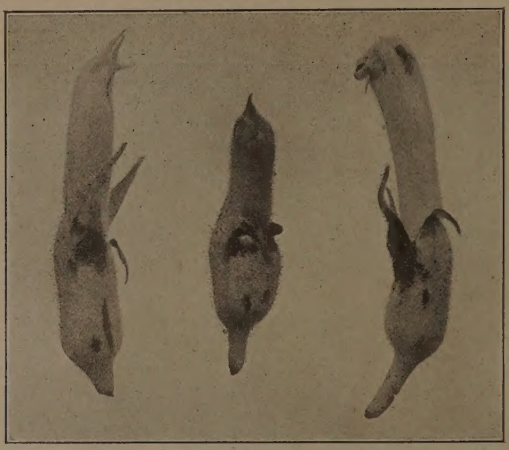

FIG. 5. — Blackfire spots on tobacco flowers. Natural size.

Cause. — Many growers firmly believe that these diseases are caused by such factors as improper fertilization, rainy weather, by cultivating at the wrong time, etc., but it has been demonstrated beyond all doubt that blackfire and wildfire are caused by parasitic organisms. Blackfire is produced by a germ known as *Bacterium angulatum,* while wildfire is produced by *Bacterium tabacum.*

The general belief that these diseases are caused by climatic and soil conditions is not without foundation, however, since rainfall is an important agency in spreading infection and in creating favorable conditions for its development, and the application of fertilizer may greatly influence the susceptibility of the plant to infection. The fertilizer or combination of fertilizers that produces the most succulent plant also results in the most severe infection, and those plants which make a very rank growth in the low, rich spots of the field become more severely diseased than the plants which make a normal growth.

Since severity of infection does not result from a lack of balance in the fertilizer but rather from a well balanced fertilizer used in the proper quantity for the best growth of the crop, there seems to be no possibility of control by modification of the fertilizer except at a sacrifice in quality and yield.

Plantbed Infection. — Infection in the plantbed is of vital importance from the standpoint of the field crop, since infection becomes established in the field chiefly through the setting of diseased plants. All efforts, therefore, at control should be centered in the plantbed with the view of producing disease-free plants for transplanting.

FIG. 6. — Wildfire spots on tobacco seedpods. Courtesy of F. A. Wolf.

Infection may become established in the plantbed in the following ways: (1) the use of contaminated seed from infected pods; (2) the use of canvas that has been used on infested beds in previous years; (3) the use of the same plantbed in successive years or the location of the plantbed in close proximity to old tobacco fields; (4) the application of manure or other material which contains refuse from a diseased tobacco crop; (5) transfer of infection from an infested plantbed to a clean one by man; (6) the chewing of the natural leaf tobacco and spitting the juice on the plants.

Proof that blackfire may be carried on the seed has been secured by planting a number of seed lots before and after disinfection and also by scattering chaff from diseased pods on healthy plants. The data with respect to wildfire are not so complete, but

evidence from field studies indicates that it is also carried on the seed or in the trash that accompanies the seed.

The canvas as a carrier of infection is fully as important as the seed, possibly even of greater importance. In a number of instances studied in farm plantbeds, infection with both diseases has been clearly traced to the use of old canvas.

Infection may readily be transferred from one bed to another on the hands or clothing of workers and especially good opportunities for this are provided in weeding and transplanting. The practice among neighbors of assisting each other in pulling and setting plants may spread infection to healthy plants when two crops are handled on the same day, or on separate days, without change of clothing.

It has been found in Kentucky, where the majority of the growers chew the natural leaf, that both wildfire and blackfire are introduced into the plantbed by spitting the juice on the young plants. In fact, this is considered the most important source of seedling infection in that State and it is probably also of importance in Virginia.

Spread of infection in the plantbed takes place most readily when the plants are wet and the splashing of raindrops appears to be the chief natural method of spread.

Field Infection. — Blackfire and wildfire are introduced into the field chiefly through the setting of diseased plants, and the severity of infection in the field is determined, in a large measure, by the degree of infection of the seedlings and also by the weather conditions that prevail during the growing season. Severity of infection is also modified by the kind and quantity of fertilizer used.

It seems to be true in some cases that infection in the field may also result from the over-wintering of the germs in the soil where tobacco follows tobacco, or from the application of manure which contains refuse from a diseased crop, and although neither of these compares in importance with the use of diseased seedlings, the possibility of infection from such sources should not be overlooked. It is believed that carry-over in the soil is possible during mild winters when the suckers are allowed to stand on the land until spring, and that danger from this source may be largely eliminated by the plowing of tobacco stubble as soon as the crop is harvested.

Control. — 1. Select seed as far as possible from disease-free pods. Cover the flower stalks with paper bags and in removing the seed snip the end of the pods to get seed free from chaff.

2. Disinfect all seed by soaking them for 15 minutes in a 1-1000 solution of corrosive sublimate, then rinse in water, dry, and store where they are not subject to re-contamination.

Caution. — Corrosive sublimate is a deadly poison when taken internally, but it does not injure the skin. Keep the solution away from children and stock.

3. The plantbed should be made up each year on new ground, well removed from old plantbeds and fields in which tobacco has been recently grown. No manure or other refuse from a recent tobacco crop should be used on the bed. Do not use poles or boards that have been used previously on the plantbed.

4. Use new cloth for the plantbed each year. If it seems necessary to use old canvas, it should be boiled thoroughly, making sure that all parts are reached by unfolding and turning it occasionally.

5. Do not use natural leaf tobacco in any form while working in or around the plantbed, and do not allow anyone else to chew tobacco while near the plantbed.

6. Examine the plants at transplanting time, discard all diseased plants, and do not use the apparently healthy plants which are located near infested spots in the bed.

7. Avoid contamination of plants at transplanting time. This is especially apt to occur when neighbors help each other in pulling and setting plants. Infection may be carried on the hands and shoes of workers.

8. As an extra precaution the plants in the plantbed may be sprayed with a 4-4-50 Bordeaux mixture. Begin spraying when the leaves are the size of the thumb nail and spray once a week until the plants are set into the field.

9. Inspect the field soon after transplanting and remove all diseased plants and reset with healthy ones.

10. Fields which have grown a diseased crop the previous year should not be planted in tobacco. Plow under the stubble as soon as the crop is harvested. Do not use tobacco refuse on tobacco fields.

11. Spraying will not control these diseases in the field. Even if this could be accomplished, such a procedure would not be practicable because of the expense involved.

Mosaic

Mosaic, sometimes called "calico," "mottled top," "gray top," or "walloon," is one of the most common diseases of tobacco in the State. Some growers consider mosaic to be a serious disease, while others regard it as of minor importance. Observations made throughout the State indicate that it reduces both the quantity and quality of the tobacco crop to a considerable extent.

Tobacco mosaic has been found to infect many plants other than tobacco, among which are tomatoes, peppers, several species of ground cherries, several species of jimson weeds, night shade, black henbane, horse nettle, beans, milk weed, celery, sugar cane, and squash. It is probable that the disease may have other hosts in addition to these.

Symptoms. — The disease attacks the plants in both the seedbed and field. The symptoms on the seedlings are, as a rule, not very noticeable unless the plants have plenty of room in the bed so that a vigorous growth is permitted. On vigorous seedlings the youngest leaves of affected plants curl downward and become pale-green in color. As the leaves increase in size, dark-green areas appear, which give the leaves a mottled appearance. In severe cases the dark-green areas develop into irregular crumpled swellings or blisters. The affected leaves often fail to develop in size and become lobed or irregular in shape. Such leaves fail to mature properly; and when cured are of poor quality.

The characteristic "mottled top" phase, with which most growers are so familiar, develops when infection occurs about top ping time and affects only the top leaves, causing them to become mottled as shown in figure 7. Plants which are severely affected are noticeably stunted. In many cases infection occurs only on the leaves of suckers. This phase is not serious since the main leaves remain unaffected.

Cause. — Although mosaic has been the subject of much investigation in this country as well as elsewhere, its cause is as yet undetermined. No definite organism or germ has been found as in other infectious diseases, but the sap of diseased plants is highly infectious, and when injected into healthy plants, will produce the disease. The disease is spread from diseased to healthy plants in such operations as transplanting, topping, suckering, and worming. This explains why the "mottled top" phase of mosaic is so common.

Dried mosaic leaves retain their infectious qualities for at least two years, but heat destroys the infectious property. The sap of diseased plants retains its infectious nature even when filtered through a filter with openings too small to permit the passage of the smallest known forms of bacteria.

Control. — Mosaic, like blackfire and wildfire, occurs in the

FIG. 7. — Leaf of tobacco, showing the characteristic mottling produced by mosaic. Courtesy of H. A. Allard.

plantbed and is introduced into the field at the time of transplanting on diseased seedlings. Just how infection is introduced into the plantbed remains uncertain; it is not seed-borne so far as is known. It is probably carried to the young plants in many cases by insects, especially plant lice and flea-beetles from perennial weeds growing near the plantbed.

Anything that causes variations in the growth of the plant seems to favor development of the disease, but it cannot be prevented to any appreciable extent by any modification of the fertilizer or by the application of lime or other materials.

In view of the fact that mosaic has its origin in the plantbed, the following precautionary measures should be observed: (1) use an insect-proof canvas and see that no openings are left around the border of the bed; (2) do not allow weeds to grow near the plantbed—they may be hosts for mosaic; (3) pull out and destroy all diseased plants found in the plantbed; (4) do not top and sucker diseased and healthy plants at the same time—make a separate trip over the field to handle the diseased plants; (5) cultivate and fertilize so as to obtain a uniform growth throughout the season.

Root Rot

Root rot, as the name suggests, is a disease that affects the roots of the tobacco plant. This disease has been of general occurrence in the State for many years, and, in the opinion of the writers, is responsible for greater losses than is generally accredited to it by growers.

Root rot is by no means limited to tobacco; it attacks many other plants, most of which are unrelated to tobacco. The list of susceptible plants includes peanuts, cowpeas, garden peas, vetch, red clover, alsike clover, crimson clover, burr clover, several weeds belonging to the legume family, cotton, watermelon, beet, carrot, and several common weeds. The cereals and some of the vegetable crops remain free from infection. The fact that tobacco often fails after cowpeas can no doubt be attributed to the presence of the root-rot organism in the soil.

Symptoms. — Root rot may occur in the plantbed or in the field. Infected plants in the bed are very much stunted and many of them die, leaving a thin stand in spots. The roots of the infected plants are partially decayed and blackened, and are stripped

off when the plants are pulled. If these plants are set in the field, new roots will form, provided the soil is warm. If, on the other hand, the season remains cool, the plants will not put out new roots and many of them eventually die.

FIG. 8. — Tobacco plants of the same age. The one on the left is dwarfed and its root system is partially decayed as a result of root-rot infection. The one on the right is normal. Courtesy of James Johnson.

Growers frequently have the experience of seeing plants set in the field apparently growing smaller instead of making a normal growth. This is a direct result of root rot. The affected plants put out new roots near the surface of the ground as soon as the season warms up, and, if the season is not too far advanced, a fair crop may be made before frost. It can be seen from the above facts that soil temperature is an important factor in the development of root rot.

Cause. — This disease is caused by a fungus technically known as *Thielavia basicola.* This organism lives as a parasite on the roots of tobacco and other host plants. It is also capable of living in the soil for many years on dead organic matter. It will eventually die out, however, if the soil is kept free of susceptible plants.

FIG. 9. — Burley tobacco, showing the value of selection for resistance to root-rot. The resistant Burley at the right shows no effect of root-rot, whereas the ordinary strains of Burley on the left are badly diseased. Courtesy of W. W. Garner.

The most common means of spreading this disease is through the transfer of infested soil, either by wind, water, farm implements, men and animals, or by transplanting diseased seedlings to healthy soil. The latter is of chief importance.

Control. — Since root rot persists in infested soil for several years, and is also capable of infecting so many plants other than tobacco, its control is a difficult matter. The plantbed infection, however, can be controlled by the use of a permanent bed which is steam sterilized every year. The practice of locating the plantbed in a new place each year also tends to prevent infection, but there is a chance even then of running into infested soil.

Infection in the field is much more difficult to handle since the soil cannot be sterilized, neither can a system of crop rotation be worked out that will control the disease and at the same time be practicable from the grower's standpoint. The development of resistant strains of tobacco seems to be the solution of the problem. In the Burley section, resistant strains of White Burley have already been developed. These resistant strains are not affected when grown on infested soil (figure 9).

Legumes are being used more and more in the dark tobacco section of Virginia, and this will doubtless in time make the development of resistant strains of dark tobacco necessary. Individual plants of the same variety vary greatly in their susceptibility to root rot, and seed from plants that remain healthy when grown on infested soil should produce resistant plants.

Black Shank

Black shank, a disease which has been the subject of considerable investigation in Florida during the past two years and which is one of the most important diseases of tobacco in that State, has been observed in several fields in Virginia. Last season four specimens of this disease were sent to the agricultural experiment station during the same week. Later in the season a field was observed in which about four hundred plants had been destroyed in an area of about one-half acre.

Heretofore black shank has been regarded as a disease of minor importance in this State, but last season's experience indicates that it is capable of causing considerable losses, and every precaution, therefore, should be taken to check its spread.

Symptoms. — Black shank usually makes its appearance in the plantbed, causing a damping-off or wet-rot of the seedlings. In mild cases of infection, dark, decayed areas form on the stems of the young plants near the surface of the ground. Many of these plants break off at the point of infection when they are pulled,

whereas others are strong enough to undergo transplanting. The characteristic symptoms on older plants is a dry, black rot of the lower portion of the stalk (figure 10). The black area near the ground level eventually girdles the stem and there is a sudden wilting of the leaves very similar to what occurs in Granville wilt. This disease, however, can be readily distinguished from wilt by the fact that there is no bacterial ooze from the cut end of the stalk.

FIG. 10. — The result of black shank on the stalk and roots of tobacco. Courtesy of W. B. Tisdale.

Cause. — Investigations in Florida have shown that black shank is probably caused by the fungus which is known technically as *Phytophthora nicotianae*.

Little is known in regard to other host plants, but there is reason to believe that the fungus is also capable of attacking other plants.

Control. — This disease must be more thoroughly investigated before specific control measures can be recommended. Nevertheless, the limited knowledge already obtained indicates that the following suggestions should prove beneficial: (1) disinfect the plant-bed by burning thoroughly; (2) do not take plants from a bed where the disease is present; (3) do not use plants from a neighbor's farm, especially if they are liable to be infected; (4) do not allow water from roads or infested fields to drain into tobacco fields or plantbeds; (5) manure from animals which have pastured on infested soil should not be used for tobacco; (6) the tobacco land should be thoroughly drained.

Root-Knot

Root-knot is the name widely used to designate a root disease of tobacco and many other plants and is very common on the light sandy soils of the South. Root-knot is known to occur in the tobacco section of Virginia, but it has not caused serious losses so far as is known.

This disease attacks the roots of plants, and, in the case of tobacco, causes the roots to become swollen and knotty (figure 11). Badly infected plants are dwarfed, wilt readily in dry, hot weather, and are usually of a paler green color than the normal ones.

Root-knot is known to attack about five hundred kinds of plants; field crops, vegetable crops, greenhouse plants, ornamentals and drug plants, shade and fruit trees, and numerous common weeds are included in the susceptible list. Fortunately, however, many plants are immune to root-knot and can be grown without injury on infested soil. Among the resistant plants are corn, barley, wheat, rye, sorghum, winter oats, redtop, timothy, peanuts, soybeans, velvet beans, cowpeas (Iron, Brabham, Monetta, and Victor varieties), Kafir, milo, some varieties of millet, and various cultivated grasses.

Root-knot is caused by a minute animal parasite, *Heterodera radicicola*, which belongs to the group commonly known as nematodes or eelworms. These nematodes are too small to be seen with the unaided eye. They move through the soil and on finding root, preferably a young one, bore their way into it. The presence of the nematode in the root irritates the tissues in such a way that the root enlarges, and forms a swelling or knot at the point of attack.

Control. — The precautionary measures as recommended for the plantbed control of wilt and root-rot are also advisable for the prevention of root-knot. The disease can be controlled in the field by the employment of a system of crop rotation in which immune crops are used. A period of three years between crops of tobacco on the same soil is sufficient to keep root-knot in check, provided other susceptible plants are kept off the soil in intervening years.

FIG. 11. — Typical symptoms of root-knot on the roots of tobacco. Courtesy of F. A. Wolf.

Wilt

Tobacco wilt, sometimes called Granville wilt, occurs in Virginia, but its distribution is not general. It has been of importance in certain localities, notably in Mecklenburg and Fluvanna Counties, but elsewhere in the State it seems to be of minor importance.

Symptoms. — This disease produces definite symptoms on the leaves, stem, and roots. The plants may be attacked in any stage of development, but the symptoms usually appear first within two to four weeks after transplanting.

The disease is first indicated by the drooping of one or more leaves of the plant. As the disease progresses, other leaves show the characteristic umbrella-like drooping, and finally the entire plant is involved. The wilted leaves become dry and eventually the plant dies (figure 12).

FIG. 12. — An area in a tobacco field where the plants are severely infected with Granville wilt. Courtesy of W. W. Garner.

A cross section of the stem at the stage of earliest wilting shows a yellowish discoloration, which becomes brownish or black in the older stages and discolored streaks are seen when the bark is stripped off. The blackening often progresses from the woody portion of the stem outward through the bark, producing dark, shrunken patches on the surface of the stem. The collection of a slimy, dirty-white ooze on the freshly cut ends of affected stalks is a reliable sign that wilt is present.

In the root as in the stem the disease first manifests itself as longitudinal streaks of black in the woody tissues near the bark.

Cause. — Tobacco wilt is caused by a bacterial organism technically known as *Bacterium solanacearum*. These bacteria live in the soil from year to year. They enter the plant through the roots and pass into the stem through the vessels that conduct water. They multiply and become very numerous in these vessels and form the slime which oozes from the cut ends of the stem.

The tobacco wilt organism is known to infect in all about fifty species of plants in nine distinct families. In addition to tobacco, the organism attacks tomatoes, Irish potatoes, peppers, eggplants, peanuts, garden beans, velvet beans, and soybeans. Many weeds and flowering plants such as castor oil bean, jimson weed, ragweed, horse nettle, dahlia, black night-shade, croton, fleabane or horse weed, and eclipta, are also subject to infection by the wilt organism.

Control. — Since the wilt organism is capable of infecting so many plants, every precaution should be taken to prevent its introduction into new fields. The two principal sources of such introduction are (1) soil from infested fields, and (2) diseased tobacco plants, either living or the dead material of leaf, stem, stalk, or root. Infested soil carried on farm implements or on the feet of animals or of men may serve to introduce the disease into a new field. Seedlings from a neighbor who has wilt on his farm may be infected and should not be used. The plantbed should be thoroughly burned.

If the soil in the field becomes infested, the only practical means of control is to resort to a system of crop rotation in which only immune crops are grown for a period of several years. Experiments in North Carolina have shown that wilt can be controlled fairly successfully by a system of crop rotation in which tobacco is grown on the land once in five years. Such crops as corn, wheat, rye, oats, sweet potatoes, cowpeas, red clover, crimson clover, and grasses, are immune to tobacco wilt and can be used in the rotation. A systematic rotation of crops will also prevent the disease from becoming established in disease-free or slightly infested fields and for that reason is a splendid practice.

Diseased palnts should be removed from the field and destroyed as fast as they appear.

Frog-Eye

Frog-eye, though of rather general occurrence throughout the tobacco section, is of very little economic importance. This dis-

ease has never been reported as causing severe losses. In fact, tobacco buyers at one time considered the presence of frog-eye spots on wrappers as an index of extra good quality and cigar manufacturers even attempted to reproduce the spots artificially in order to make their goods more popular.

Some farmers in this State contend that wildfire and blackfire are simply severe forms of the long-known frog-eye. This view is entirely without foundation.

This disease apparently does not attack the leaves until they have attained mature size or have begun to ripen. This explains why the lower leaves are always first to show infection. The spots are circular and brown in color, with grayish-white centers and dark brown borders. As a rule, infection is restricted to those leaves which would fall into the sand-lug grade and consequently the loss is slight.

The cause of frog-eye is attributed to a fungus technically known as *Cercospora nicotianae,* but definite proof that this fungus is the primary cause of the spot has not been established.

Any factor, such as excess soil moisture, deep cultivation late in the season, or root rot diseases, which checks the growth or causes premature ripening of the leaves, may predispose the plants to frog-eye infection. Therefore, the grower should fertilize and cultivate so as to maintain a uniform growth throughout the season.

Ring-Spot

Ring-spot, generally called ring-worm by growers, occurs rather commonly in Virginia tobacco fields. In the majority of cases only a small percentage of plants are affected, but in rare cases the percentage of infection runs very high and the quality of the crop is greatly reduced.

The spots are small and white (they may be brown when first formed) and form irregular patterns of rings and zigzags on the leaf. In some cases the markings on the leaf are so arranged as to form beautiful designs resembling those used in fancy needle work. The spots are most numerous near the veins as shown in figure 13.

The cause of ring-spot has not been determined. The disease has been regarded by some investigators as a form of mosaic, by others as the work of thrips (small insects that cut the leaf with a

saw-like apparatus while depositing their eggs), and by still others as a result of some disturbance in the nutrition of the plant.

Evidence thus far obtained, though not at all conclusive, tends to support the latter view. This is suggested by the location of the spots with reference to the veins of the leaf; also by observations that affected plants are often restricted to certain areas in the field, especially where old buildings have stood or on the site of former gardens. This view is also supported by the very gen-

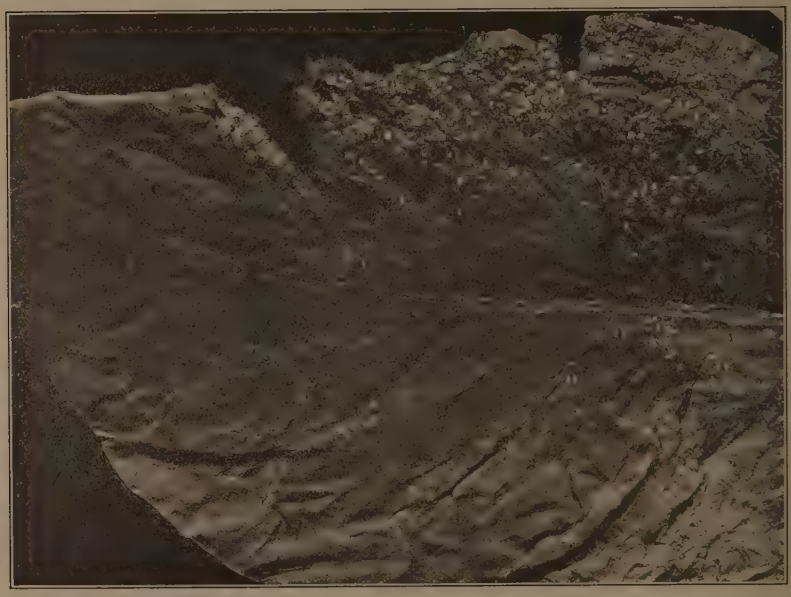

FIG. 13. — Ring-spot on a tobacco leaf. Greatly reduced.

eral occurrence of ring-spot on land where tobacco follows clover or other forage crops. Fields have been observed where 50 per cent of the plants were affected, and the only apparent reason for it was the fact that a clover crop had been turned under. This evidence, on the other hand, can be applied just as readily to the thrip theory because thrips are usually very abundant around the sites of old buildings and former gardens, and also in old clover fields.

In the light of our meager knowledge concerning this disease, nothing specific can be recommended as a remedial measure except to provide a properly balanced plant-food supply and to avoid an over-supply of organic matter in the soil. All varieties of tobacco appear to be equally susceptible.

Frenching or Shoe Strings

Frenching, although frequently confused with mosaic, is now known to be an entirely distinct trouble. The two diseases frequently occur on the same plant and this has led to their being confused. Frenching occurs in Virginia to some extent, but as a

FIG. 14. — Bud leaves of a young tobacco plant affected with frenching. The older leaves are normal. Courtesy of W. W. Garner.

rule, it is of slight importance. Occasionally, however, it causes severe injury.

The symptoms vary greatly; in severe cases the dwarfed stems are thickly clothed with dagger-shaped leaves, no more than an inch wide, while in milder cases the leaves are abnormally thick and leathery, curl downward, become crinkled, and remain very narrow. In some cases only the top leaves are affected.

This disease is not infectious; it is caused by some unfavor-

able condition of the soil. Defective drainage and a deficiency of plant food are the factors with which it is most commonly associated, but it has been known to occur in some instances after

Fig. 15. — Tobacco plants severely dwarfed by frenching. Courtesy of F. A. Wolf.

heavy applications of commercial fertilizer. The new growth on affected plants may become normal when the unfavorable condition in the soil is corrected.

Adequate drainage and the application of a properly balanced fertilizer should aid materially in correcting this trouble. Frequent cultivation should prove beneficial on heavy soils.

Drought-Spot

This trouble occurred very commonly in the tobacco fields of the State during the very dry season of 1921, and led to much confusion among farmers by whom it was often mistaken for blackfire or wildfire.

Symptoms. — The leaves of the plant are affected and spots appear which are restricted to the tissue between the larger veins, and to the leaf margins which are usually rolled downward. The spots are roughly circular or more commonly are irregularly lobed. It is not unusual for the spots to run together, involving large areas of the leaf as shown in figure 16. They vary greatly in size from about one-fifth to four-fifths of an inch in diameter and are

brown in color. The margins of the spots are definite and marked by a darker line, and are bordered by a yellow zone which diffuses into the normal green of the leaf.

Cause. — Drought-spot is evidently brought about by a lack of balance in the water supply within the plant. Under very dry soil conditions, such as obtained generally during the summer of

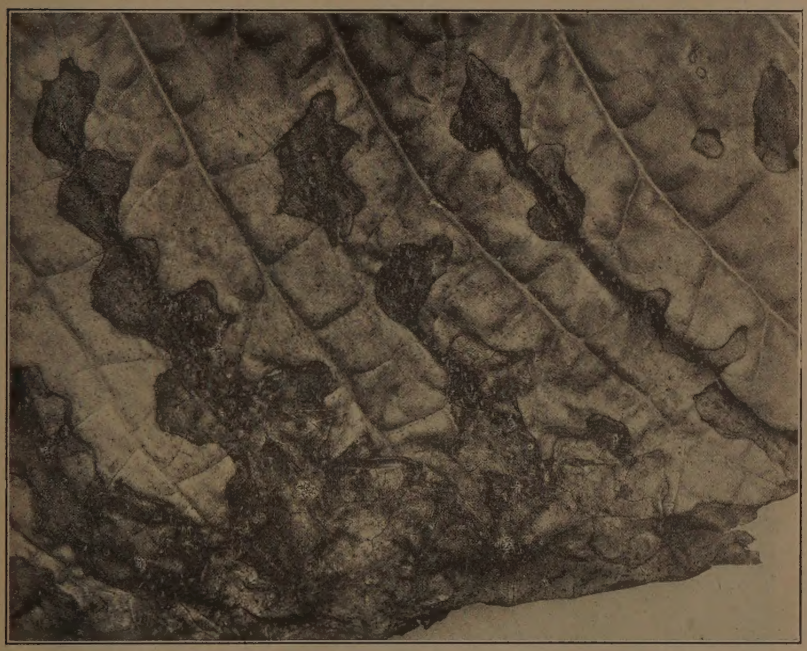

FIG. 16. — A portion of a tobacco leaf affected with drought-spot. Note the relation of the spots to the veins and leaf margin. Natural size.

1921, the quantity of water given off in transpiration is apt to exceed the amount taken in by the roots. The tissue the greatest distance from the principal veins is especially apt to suffer from lack of water and death of groups of cells on the leaf margins and between the veins results, causing the spots as described above.

Since drought-spot is primarily a dry weather disease, there is very little that can be done to prevent it, but such measures as tend to preserve soil moisture should decrease the amount of injury.

Lightning Injury

Tobacco fields are not uncommonly struck by lightning during severe electrical storms and the injury produced is so readily confused with that which might be caused by a parasitic disease that a brief description should be given. The plants are affected in well defined spots in the field which vary in size up to 30 hills in diameter. These spots may be circular or elongated in the direction of the ridges. The injury is greatest at the center of the spot and diminishes towards the borders. Some of the plants are killed outright and these show severe stem injury. The stems are browned or blackened, especially near the base, and are shrunken and often ridged. They are triangular in shape when cut across,

FIG. 17. — A portion of a tobacco plant, showing the effect of lightning injury. Note the black, shrunken condition of the midribs of the leaves.

and the pith, especially near the base, is browned and dried as in cured stalks. The leaves are browned and hang downward. Other plants show little or no stem injury, but the midribs of certain leaves, particularly the upper ones, are browned and shriveled in

part (figure 17). Such leaves remain green and as they continue to grow they become puckered and twisted and curved to one side. The new leaves which are produced above the injured ones are normal and the plant may survive until harvest.

The positive signs of a lightning stroke are the sudden appearance of the injury, the breaking down of the pith, the browning of the midribs and the crinkling and twisting of the leaves.